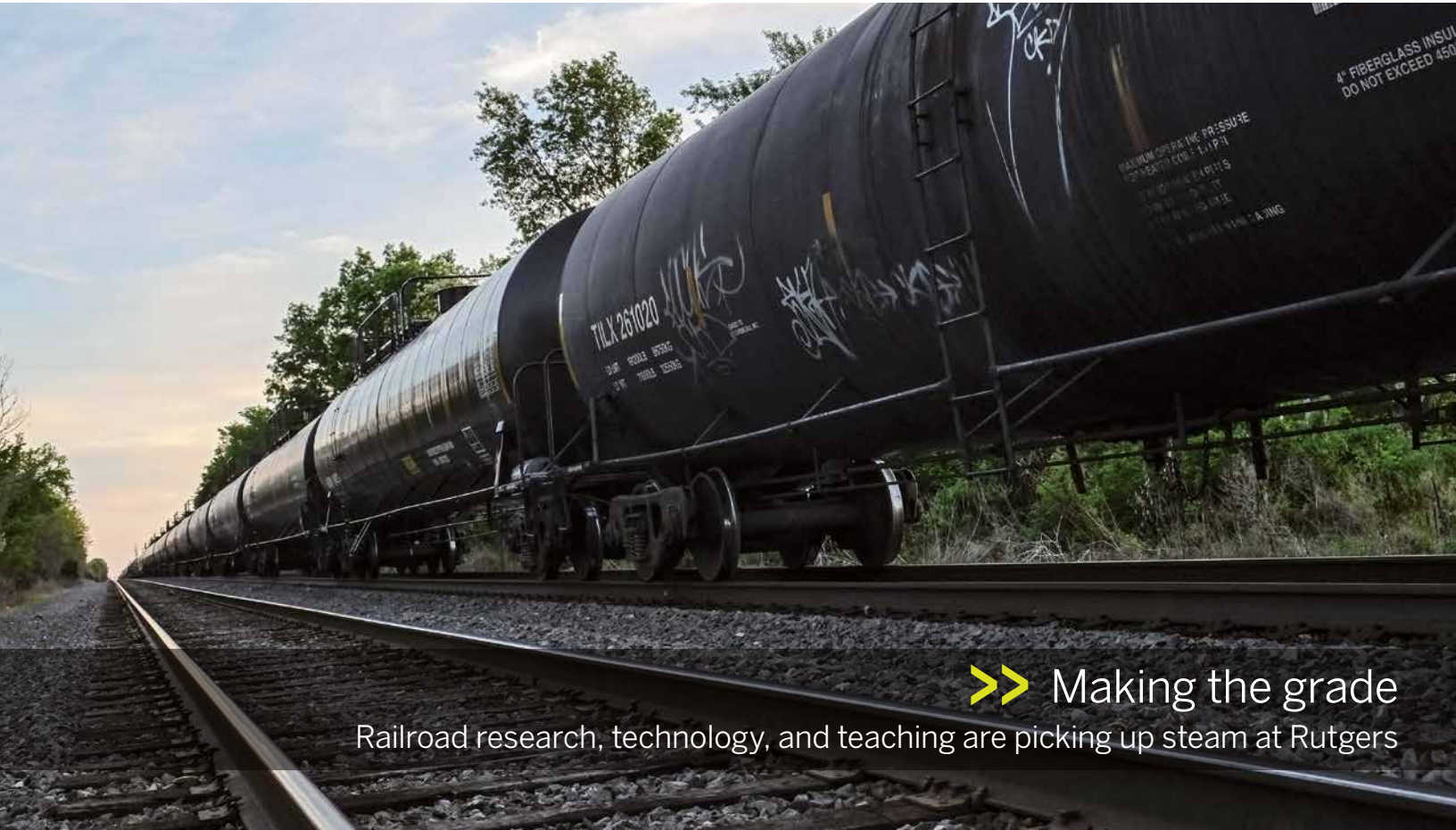


## transportation today



## &gt;&gt; Making the grade

Railroad research, technology, and teaching are picking up steam at Rutgers

## inside

In spite of the dense railroad network in the New York-New Jersey metro area, no university in the region has a focused railroad research and education program. Rutgers is changing that.

In a state crisscrossed by 984 miles of railroad track, Dr. Xiang Liu, assistant professor in the School of Engineering's (SOE) Department of Civil and Environmental Engineering and a CAIT-affiliated researcher, is bringing his commitment, fresh ideas, and youthful energy to expanding rail research and curriculum at Rutgers. At the same time, he is helping railroads do business more safely and efficiently.

Liu sees an opportunity for Rutgers to fill the rail education and research void by developing cutting-edge technological solutions for the industry and being a source of well-"trained" talent that

railroads will need in the near future. He is confident that Rutgers' well-established existing relationships with the rail industry—including those with the USDOT Federal Railroad Administration (FRA), Association of American Railroads (AAR), Amtrak, Conrail, CSX Transportation, MTA, NJ Transit, PATH, Port Authority of New York and New Jersey, and others—are a strong foundation for cultivating even more partnerships.

With well-deserved recognition for his work and more than \$1 million in research contracts, Liu's efforts are clearly on the right track. He is the principal investigator on several research

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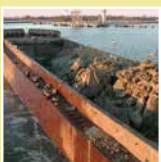
## &gt;&gt; p7

It's big and bad, and if you see it in action, it will shake you to the core.



## &gt;&gt; p9

There's something in the air. Get used to it—the drone market is just getting started.



## &gt;&gt; p15

New methods to process and use contaminated sediment from NY/NJ waterways.



## Uncertainty calls for perseverance

Every four years, the American Society of Civil Engineers' Report Card for America's Infrastructure provides a snapshot of the condition

and performance of U.S. roads, bridges, water systems, and energy networks. The country's infrastructure earned a grade of D+ in the 2017 ASCE Report Card, the same as it did in 2013. By their measures, across all categories, we are not making much progress, mainly due to insufficient investment.

For decades, transportation agencies have been sounding the alarm, and asking researchers to find ways to do more with less to preserve our assets. CAIT has risen to the challenge with breakthroughs in nondestructive evaluation, first-of-its-kind condition assessment tools, asset management systems, big data modeling, innovative materials, and hundreds of training courses for transportation's "boots on the ground."

Infrastructure—which is clearly crucial to the economy and American's quality of life—has historically been one of the few issues that lawmakers on both sides of the aisle agree on.

There are over 50 pieces of infrastructure legislation in Congress right now. There are even a few bipartisan efforts, such as the bill proposed by Senators Cory Booker (D-NJ) and James Lankford (R-OK) to close some of the funding gaps by ending subsidies for professional sports stadiums. These proposals are cause for optimism.

President Trump spoke of his infrastructure investment plans frequently on the campaign trail and since his inauguration, saying, "We're going to rebuild our infrastructure, which will become, by the way, second to none. And we will put millions of our people to work as we rebuild it."

Professionals who are faced on a daily basis with evidence of exactly how many high-value assets are in critical condition, eagerly await a comprehensive infrastructure plan and can't afford to give up hope. None of us can.

Case in point: the North River rail tunnel under the Hudson River, the only rail connection between New York City and points north and south of it in the Northeast Corridor. Badly damaged by Hurricane Sandy in 2012, about 450 Amtrak and NJ Transit trains carry more than 200,000 people through the tunnel every weekday. Breakdowns clogging one of its only two tracks, congestion delays, and recurring repair closures beg the

question: Exactly how much longer do we expect 110-year-old cast iron tubes underwater to last?

There are some items in the new tax bill related to infrastructure, but industry advocates argue that our transportation, water, and energy network issues are so complex and so important that they need a stand-alone bill. In fact, according to Michael R. Bloomberg of Bloomberg News, provisions of the new tax bill could hurt more than they help. "Restricting state and local tax deductions will also mean less local investment for infrastructure, and by raising deficits, the bill will constrain federal infrastructure spending," he said.

"Failure to find the revenue for an infrastructure initiative now, as part of tax reform, will make passage of such a package nearly impossible in the future," said Bud Wright, executive director of the American Association of State Highway and Transportation Officials, in a letter to Congress.

The Highway Trust Fund, the main source of federal transportation money, is teetering on insolvency. For the last decade, Congress has repeatedly tapped other sources for revenue, but no apparent long-term plan has emerged.

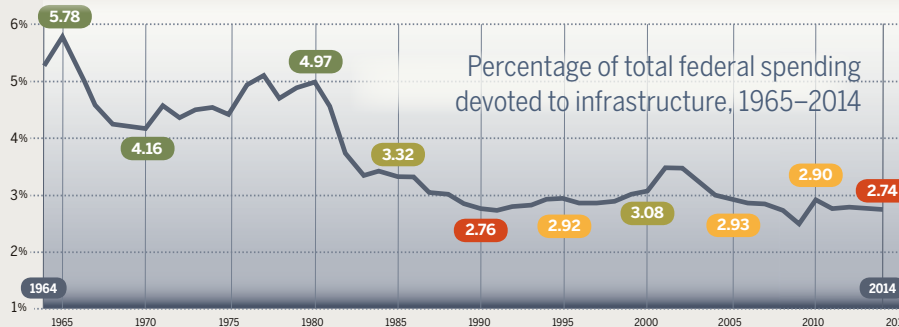
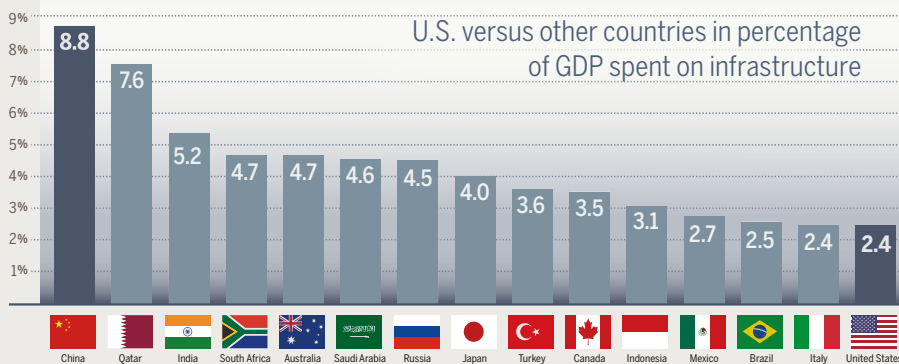
The decline in real spending on transportation and water infrastructure in recent years has dwindled most significantly at the federal level. Since 2003, federal backing has fallen by about 19 percent, while spending by states and local agencies has dropped only around five percent. Federal infrastructure spending in the past was typically much greater; in 1977, it was 38 percent. Now, at barely 25 percent, it is lower than at almost any time in the past 60 years, transferring the burden of rising costs for materials, labor, real estate, and other capital expenses on to state and local governments.

Based on percentage of GDP, the United States ranks 15th globally for infrastructure investment. China has lapped us nearly four times over at 8.8%, but Brazil, India, Indonesia, Russia, Turkey, and others also outspend us.

As the saying goes, there is no free lunch. Likewise, there are no free roads, bridges, railways, or airports. We sincerely hope officials will work on an infrastructure package after the tax overhaul, as they have promised. But now that tax reform has passed, it seems priorities have already shifted for some congresspeople.

The focus of research is to find better and more economical ways to extend the life span of our current assets and build new ones that are more durable and resilient—and do that without breaking the bank. We will persevere in that quest and continue to support lawmakers who are actively working to solve the chronic shortfall in America's infrastructure funding. ■

Ali Maher, Ph.D., Director



Source: Congressional Budget Office based on data from the Office of Management and Budget and the Census Bureau.



<< p1 Making the grade

projects that will provide FRA and the railroads with insight on important safety and operational concerns. The work encompasses topics pertinent to both freight and passenger rail: asset management, big-data analytics, advanced train control operations (e.g., positive train control), risk analysis, cybersecurity, and digital railways, aka the Internet of Railway Things.

**Calculating risks of crude oil trains**

A project that CAIT sponsored with UTC funds springboarded Liu’s research to develop a systematic, comprehensive methodology for analyzing risk of derailment and the release of hazardous materials that may result. Specifically, Liu’s model focused on trains carrying crude oil. The research he did on the subject earned him the 2017 Outstanding Research Contribution Award from the

Transportation Research Board (TRB) Hazardous Materials Transportation Committee, as well as a Young Member Best Paper Award from the TRB Railroad Operational Safety Committee.

Production of crude oil surged in the United States, from about 1.83 billion barrels in 2008 to 3.43 billion barrels in 2015. A lot of the additional production is transported by rail. In 2008, U.S. Class I railroads carried 9,500 carloads of crude oil. In 2014, they carried more than 493,000 carloads, an increase of more than 5,000 percent. (Source: AAR)

Transporting crude oil by rail is a complicated issue. Oil is a huge part of the U.S. economy. It doesn’t just fuel our vehicles; its derivatives and byproducts are used in thousands of common products, from asphalt and plastic to consumer goods, such as soap and vitamin capsules.

This valuable, versatile commodity needs to get from its origins, mostly in the Midwest and South, to refineries on the East and West coasts. Current pipeline capacity can’t keep pace with production, and the oil industry sees rail as the next best option.

One big advantage of transporting commodities by rail is fuel efficiency. Last year, BNSF moved each ton of freight about 500 miles on a single gallon of diesel fuel—or about three times more efficiently than long-haul trucks. It also is far safer than trucking. In 2015, 4,067 people died in accidents involving freight trucks, which accounts for almost 88 percent of all freight transportation fatalities and 11.6 percent of all highway deaths for that year. By comparison, there were 502 freight train fatalities in 2015, including accidents involving trespassers (302 deaths) and crashes between trains and motor vehicles at at-grade

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How many railroads are operating in the United States and how are they different?

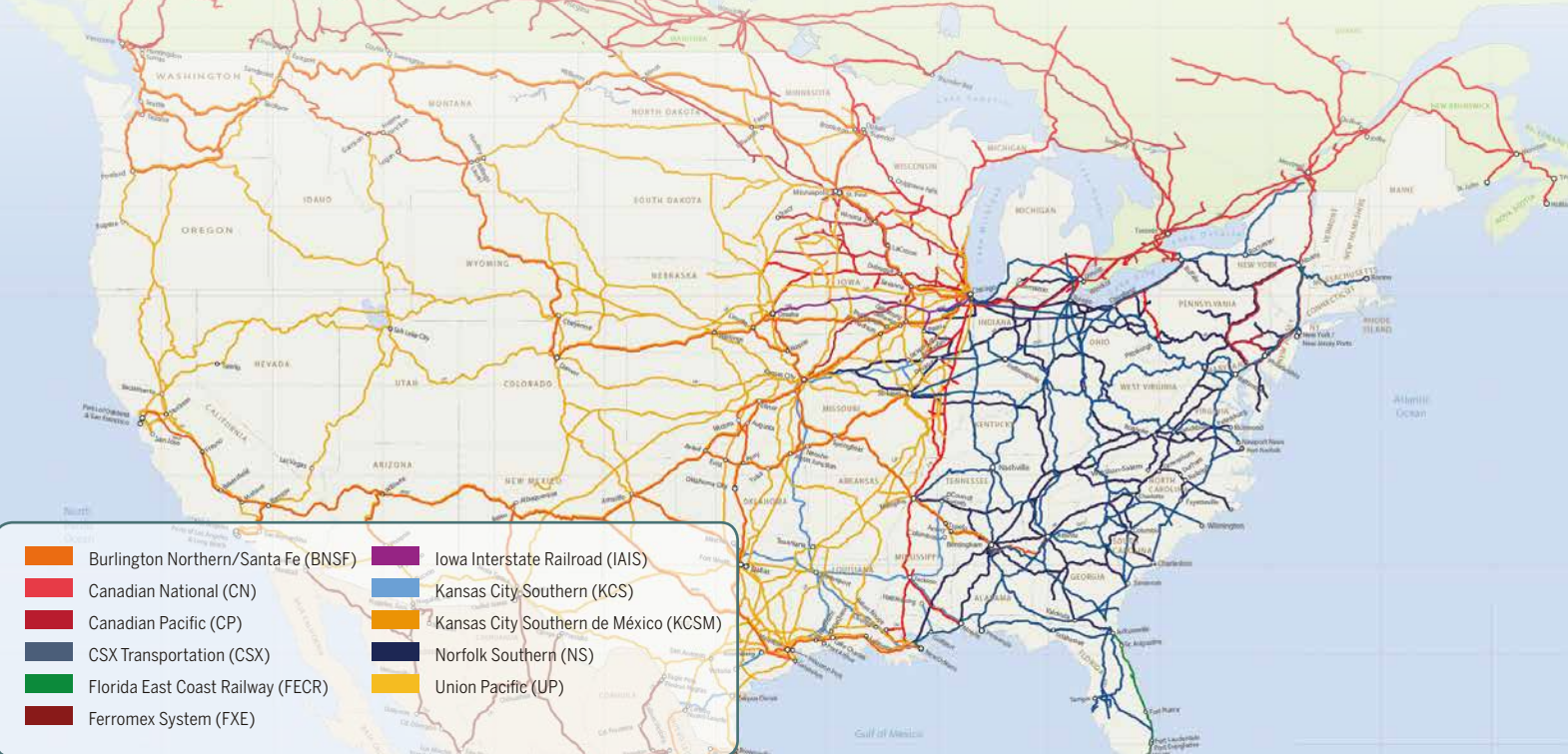
Every day, the nation’s **560 railroads** deliver an average of five million tons of goods.

There are **seven long-haul, intercity Class I railroads**. Many are household names, such as BNSF, CSX, Norfolk Southern, and Union Pacific.

**Passenger railroads** typically operate on tracks owned by freight railroads. About 70 percent of the miles traveled by Amtrak trains use freight tracks. Also, **commuter lines** carry hundreds of millions of riders using tracks or right-of-way owned by freight rail companies for at least a portion of their route.

**Short line and regional railroads** operate in every state except Hawaii and account for 31 percent of U.S. freight rail mileage. They range in size from small operators handling a few carloads a month to interstate operators that are nearly as robust as the Class I carriers.

Lastly, **switching and terminal railroads** usually perform pickup and delivery services and operate within a port or industrial area, or move traffic between other railroads.



This map shows the major railroads in North America. ©2010-2017 Intermodal Association of North America. All rights reserved.



“The rail industry is embracing new technologies and management strategies to improve safety.” — Dr. Xiang Liu

A 2015 derailment near Mt. Carbon, West Virginia, involved 27 crude oil tank cars that released 378,000 gallons of crude oil near the Kanawha River, the source for two counties' drinking water. One home was destroyed and one person was treated for smoke inhalation. Photo: U.S. Coast Guard, Chief Petty Officer Angie Vallier.

#### ◀ p3 Making the grade

roadway crossings (155 deaths). Only one person died as a result of a train-only accident. (Source: Bureau of Transportation Statistics)

These statistics show rail transport is far safer than trucking, at least in terms of related deaths. Still, people's concerns about crude oil trains are not entirely unwarranted.

In the 37 years spanning 1975 and 2012, federal records show 800,000 gallons of crude oil were spilled in train accidents. In 2014 alone, that jumped to more than 1.15 million gallons, according to an analysis done by McClatchy Newspapers using data from the Pipeline and Hazardous Materials Safety Administration. Also in 2014, high-profile crude oil spills caused a serious fire in Virginia, contaminated groundwater in Colorado, and destroyed a building in Pennsylvania. These three incidents resulted in at least \$5 million in damages and the loss of 57,000 gallons of crude.

David Willauer, vice chair of the TRB Committee on Transportation of Hazardous Materials, and chair of the TRB Subcommittee on Crude Oil Transportation, says the huge increase in volume of crude being transported presents new problems for the industry.

During the 19th century westward expansion of the United States, railroads were built to link centers of commerce and many towns and cities sprung up beside them. Suburbanization, which boomed after WWII and continues its creep today, created even more residential development, in many cases, within feet of the tracks.

The combination of residential proximity, transporting more crude oil by rail, and widely reported derailments and spills has led to sharper scrutiny by the media and louder protestations from the public. It is possible, however, that media attention is causing a distorted perception of danger. This seems to be supported by the fact that even as use of rail has dramatically increased, AAR reports that accident and derailment rates per million train miles are both down 44 percent since 2000, based on 2017 FRA safety statistics. So, which is right, FRA stats or media reports? Liu's research helps shed light on the actual probability of dangerous crashes.

#### Exactly how risky are “bombtrains”?

When the public judges the threat posed by crude oil trains based on headlines alone, they aren't getting the full picture. Liu's report describes a practical, data-based probabilistic risk analysis

(PRA) model to estimate the in-transit risk of transporting crude oil in a unit train. Unit trains carry a single commodity in one type of rail car; they are more operationally efficient than mixed trains that carry a variety of products and commodities and are made up of multiple car types (e.g., boxcars, hoppers, and tankers).

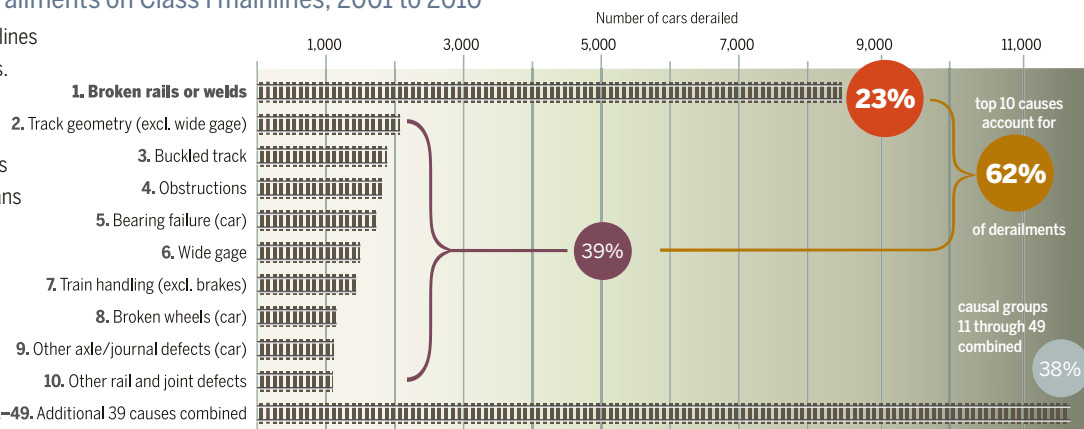
His methodology incorporated factors having to do with infrastructure and operational characteristics such as track quality, train speed, type of traffic operation (i.e., unsignaled versus signaled), annual traffic density, and population density along the rail line. He also factored in aspects having to do with the train itself, such as train length; point of derailment (the position of the first car derailed); the total number of tank cars; and whether cars are the old tankers or the new safety design.

Using these inputs, Liu's methodology estimated probabilities 1) for a train derailment, 2) for a tank car derailling based on its position in the train's configuration, 3) for a derailed car releasing its contents, and 4) for estimated consequences of a spill.

The final product was a computer-aided decision support tool that automatically calculates risk values for variables like different track types, rolling stock, and operational characteristics.

## Primary causes for freight train derailments on Class I mainlines, 2001 to 2010

Primary causes of derailments on Class I mainlines are divided into 49 categories or causal groups. Broken rails or welds are, by far, the most common, accounting for 23 percent of total cars derailed during 2001–2010. Causal groups 2 through 10 account for 39 percent. That means the top-10 causal categories are responsible for 62 percent of cars derailed. The other 39 identified causal groups *combined* account for the remaining 38 percent. Since broken rails are responsible for most derailments, Liu and others conclude preventing them is likely a promising risk-reduction strategy.



## Safety is literally riding on the most common cause of derailments

Calculating risk is just one part of railroad safety. Understanding underlying causes of accidents is equally important. Liu found through his earlier research that broken rails have been the leading cause of freight train derailments over the last 10 years.

The FRA determined a broken rail was the primary cause of a February 2015 headline-grabbing accident in West Virginia that involved 27 crude oil tank cars. Immediately following the derailment, two punctured cars released their contents and caught fire. The fire spread, eventually leading to thermal tears in 13 additional derailed tank cars. Some of the spilled crude leaked into the Kanawha River, which is the source of drinking water for two counties.

Ultimately, all but three of the derailed tank cars sustained significant damage, one home was destroyed, and 378,000 gallons of crude oil were released during the incident. Thankfully, only one person suffered smoke inhalation and the river was not significantly contaminated. (Source: FRA Accident Findings Report for Unit Crude Oil Train K08014)

Obviously, FRA and railroad operators have a keen interest in anything that will help avoid incidents of this magnitude, visibility, and economic and human impact. In another FRA project, Liu will develop a framework to help manage the risk associated with broken rails.

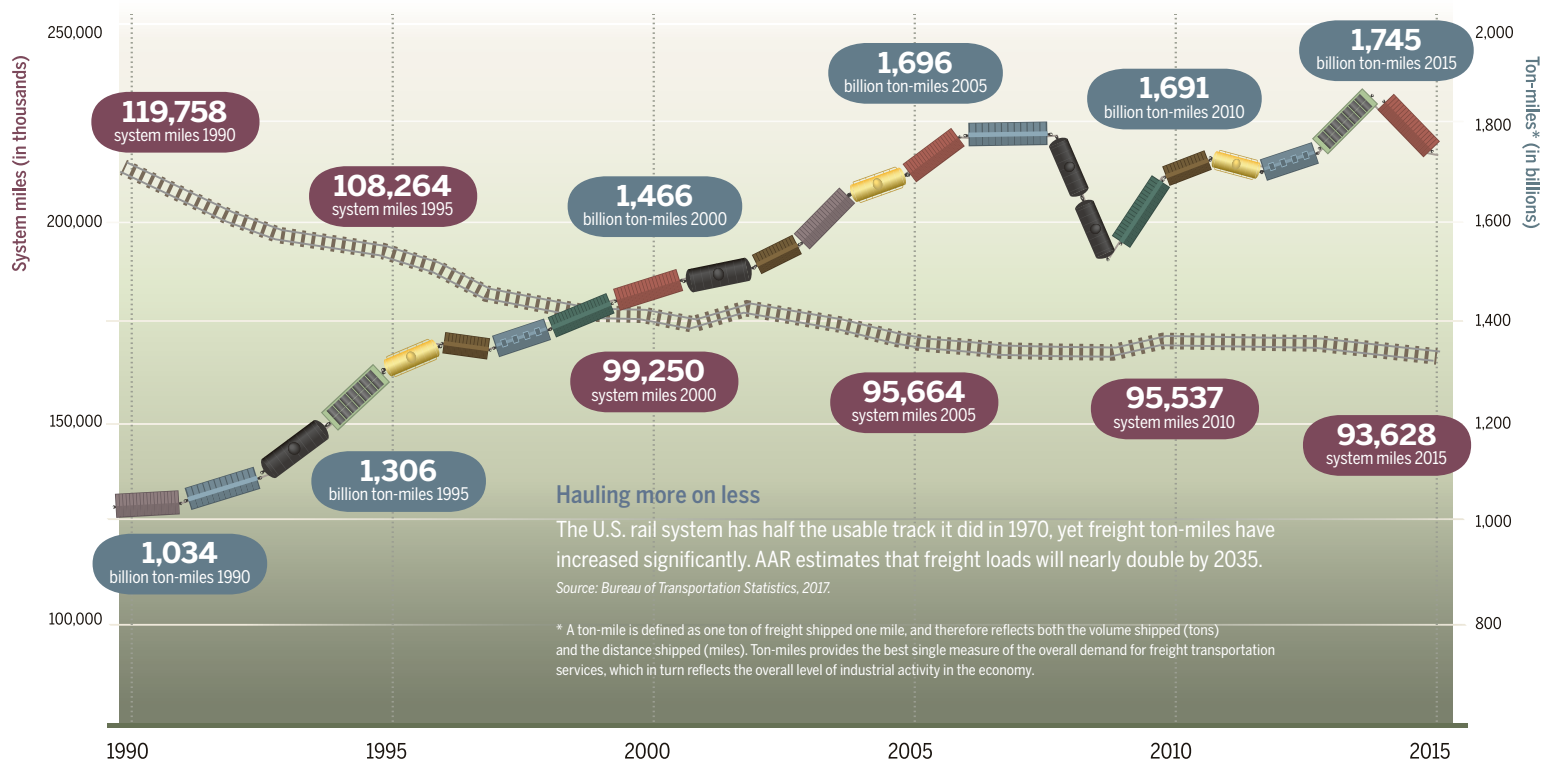
Rail infrastructure inspection practices have evolved to employ new, data-gathering technologies—e.g., LIDAR, GPR, ultrasonics, and laser measurement tools—and systems that analyze and interpret the data. This approach now drives objective, centralized, data-based decisions about upkeep of the 140,000-mile-long network. “The industry can implement proactive, risk-based asset management,” Liu explains. “This will be an improvement over a reactive maintenance strategy used in the past.”

## Pump the brakes

Another project Liu is working on aims to determine cost/benefit implications for using positive train control (PTC), even when trains are operating at or below restricted speeds. PTC is a sophisticated, intelligent technology

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## Usable rail-system miles versus ton-miles hauled, 1990–2015





designed to automatically stop a train before it derails or crashes. Currently, regulations don't require PTC to be activated while a train is traveling under restricted speeds.

Delving into historical data on train accidents and their underlying causes, the research team will identify accidents that may have been prevented if restricted-speed PTC was being used. They will thoroughly analyze the identified accidents and their consequences (property damage, casualties, etc.) to quantify future accident risk.

The operational impacts of restricted-speed PTC also must be weighed. Will this practice negatively influence scheduling or cause delays? How reliable is the technology? How quickly will the workforce adapt to restricted-speed PTC? Liu explains, "The impact of PTC on the rail industry is similar to that of connected vehicles on highway. The industry is stepping into the stage of communications-based digital railways, leading to a new array of questions related to cost-efficient implementation of PTC, cybersecurity, and optimal train operations based on this technology."

In addition to examining the safety benefits, economics, and technical and operational feasibility of PTC deployment at or under restricted speed, the team also plans to investigate possible alternatives that may provide equal or greater safety benefits for the same or lower costs. This comprehensive assessment will give regulators and railroad operators a complete picture on which to base their decision on the matter.

### Supply chain for a new railroad workforce

Over the next five to 10 years, around 50 percent of the current rail workforce will retire. Liu thinks Rutgers can be a pipeline for knowledgeable, prepared railroad engineers and professionals.

Liu has become Rutgers' "railroad evangelist," volunteering to bring together faculty that already are working on railroad technology, recruit other engineering disciplines, and build partnerships with Rutgers Business School and the Bloustein School to form a cohesive, multidisciplinary program encompassing engineering, management, finance, and planning.

**“Years ago, the question was, ‘How do you keep railroads from dying?’ Now, it’s ‘How do you make them thrive?’” —Dr. Xiang Liu**

Not forgetting that teaching is a crucial ingredient of a truly comprehensive university-based program, he also is developing a new “rail-centric” academic program for engineering students. Liu established the first-ever railroad engineering overview course at Rutgers in 2015. For the fall 2017 semester, he added a new track-engineering course. He also organized and co-advised

a Rutgers student chapter of the American Railway Engineering and Maintenance-of-Way Association (AREMA). The student chapter is supported by AREMA and the New Jersey Short Line Railroad Association.

This creates opportunities for students to interact with and be inspired by industry professionals, and for the industry to glimpse the wealth of talent and knowledge available at Rutgers.

### The light at the end of the tunnel

More freight is moved on 140,000 miles of U.S. rails than on any other system in the world. AAR reports in 2015, freight railroads employed about 169,000 people who earned an average of \$121,000 in wages and benefits—that's about 55 percent higher than the average for other full-time U.S. workers. Total industry revenue for 2016 was nearly \$70 billion, and, according to the AAR, railroads invested an average of \$28 billion annually for the past three years on infrastructure and equipment.

Moving goods—and people for that matter—by rail reduces roadway congestion, fuel consumption, and greenhouse gas emissions. In 2014, nearly 118.5 million tons of freight originated in, terminated in, or moved through New York and New Jersey by rail. If not for trains moving that freight, it would have been transported by truck, adding 6.6 million more tractor trailers and other heavy vehicles to our already choked roadways.

(Sources: National Railway Labor Conference/AAR/FRA)

The U.S. rail system has half the usable track it did in 1970, yet freight ton-miles have increased significantly. (See the graph on page 5.) AAR estimates that freight loads will nearly double between now and 2035. Increased demand minus half the miles of track to fill demand equals congestion. That's the equation for an industry ripe for investment.

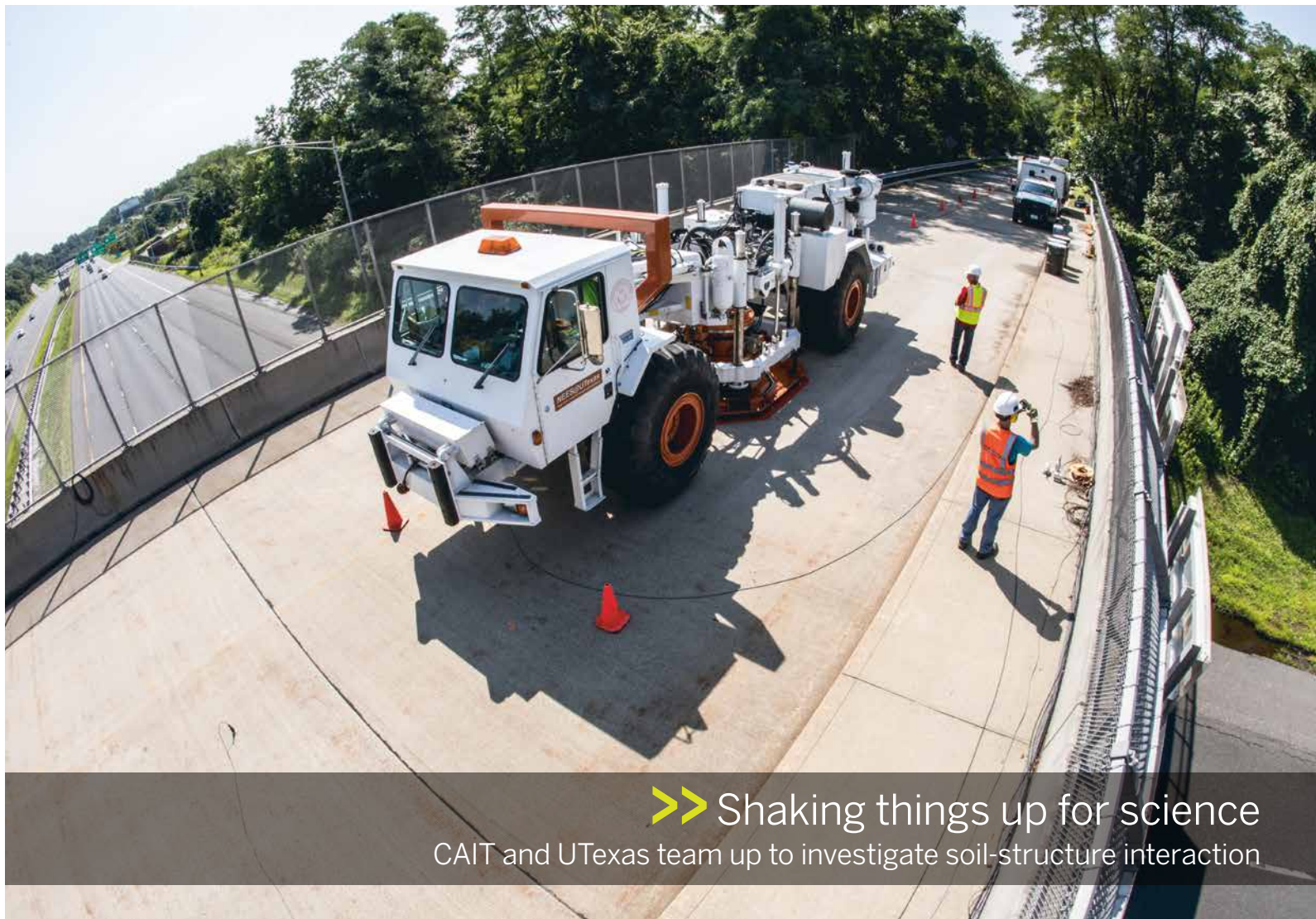
Liu is convinced the railroad industry is both viable and sustainable. “Warren Buffett bought the Burlington Northern Santa Fe railroad a few years ago. He doesn't buy dying companies. And he's conservative,” Liu says. “Years ago, the question was, ‘How do you keep railroads from dying?’ Now, it's ‘How do you make them thrive?’” He's positioning Rutgers to fuel that rejuvenation in the Northeast Corridor.

There's a saying: “I can see the light at the end of the tunnel, but it's an oncoming train.” Liu turns that colloquialism on its head. In his mind, that light is the bright future for U.S. railroads, heading straight for us and picking up speed. ■

Left: For one FRA project, Liu will develop a framework to help manage the risk associated with broken rails, which are the leading cause of derailments.

Photo: ©Allison Thomas





## >> Shaking things up for science CAIT and UTexas team up to investigate soil-structure interaction

One of many factors at play in the built environment is dynamic soil-structure interaction; the relationship between structures and the ground they are built on and surrounded by.

Aging bridges, buildings, and other infrastructure pose significant safety and economic risks, particularly in extreme natural events, such as earthquakes, when dynamic soil-structure interactions (DSSI) are amplified and hard to predict.

Since the late 1970s, engineers have experimented with various methods to better understand DSSI. In the early days, they relied on visual inspections and simple simulation models. But the study of DSSI has evolved over the decades. It now incorporates an impressive array of sensing technologies, highly refined simulation models, model calibration techniques, and forced vibration testing.

Above: Last August, CAIT and NHERI@UTexas cohosted a two-day workshop to highlight NHERI's equipment for testing soil-foundation-structure systems. The first day of presentations was followed the next day with a field demonstration of NHERI's T-Rex on a bridge in Hamilton, New Jersey. The bridge was identified as good candidate for forced vibration testing by NJDOT, who also facilitated the demo.

Photo: ©Drew Noel Photography/Rutgers CAIT

The field that emerged, Structural Identification (St-Id), is growing fast and considered a crucial tool in developing safe, cost-effective approaches for adapting and reusing existing infrastructure.

CAIT has partnered with the University of Texas Natural Hazards Engineering Research Infrastructure (NHERI@UTexas) program on a National Science Foundation (NSF) research project to measure performance of the superstructure, substructure, and foundation of existing structures in the built environment. The project aims to quantify structural performance with real, rather than model-based, data that is more accurate than can be gathered from testing under operational conditions, or from traditional forced vibration testing, which is constrained to low-amplitude excitation in one direction. The researchers are using technology that allows them to go far beyond the limitations of current data collection and testing methods.

Their secret weapon is NHERI's mother of all forced vibration testers, a monster shaker dubbed T-Rex.

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Images from the structural testing workshop field demonstration with T-Rex. In addition to its large-amplitude 3D load-generation capabilities, T-Rex also is outfitted to push cone penetrometers and other custom-made vibration and/or pressure-sensing instrumentation into the ground using a hydraulic ram. NHERI@UTexas equipment is primarily funded by the National Science Foundation (NSF) and has served the earthquake engineering community for over 10 years. Photos: ©Drew Noel Photography/Rutgers CAIT.

## << p7 Shaking things up

T-Rex is the only one of its “species” in the world. It is a mobile high-force, hydraulic triaxial shaker capable of generating large dynamic forces in three directions: vertical, horizontal in-line, and horizontal cross-line. The shaking apparatus is incorporated into a large off-road, all-wheel-drive vehicle that can handle almost any terrain.

With T-Rex’s large-amplitude 3D load-generation capabilities, researchers can vary and more tightly control frequency waves to get a “cleaner” recording of a structure’s response.

The maximum force output of T-Rex’s shaker is about 267 kilonewtons (approx-

mately 60,024 pounds-force) in the vertical mode and about 134 kilonewtons (approximately 30,124 pounds-force) in each horizontal mode.

T-Rex can push the structure-foundation system beyond low-level response using a more realistic distribution of forces at much greater levels. This will reveal characteristics and behavior between dynamic soil and structures that are typically only at play in extreme events, like earthquakes or storm surges.

The knowledge gained through this research will be used to optimize future infrastructure design and ultimately make communities more resilient. ■

## Dynamic structure-soil interaction for dummies

When constructing an office building, bridge, or other structure, if bedrock is inaccessible, most often soil is what supports its foundation. As such, the structure and the soil are an interdependent, complementary system.

If the relationship between the foundation and the soil is not properly accounted for in the structure’s design, extreme dynamic loads—like those from wind and earthquakes—may cause the structure to behave unpredictably. The magnitude of displacement (distance and direction the structure or soil moves) and/or forces acting on structural members (like columns, beams, and walls) could be lower than predicted, but also could exceed what the structure can safely handle.

The relationship between certain structural and soil characteristics can lead to particularly strong dynamic soil-structure interaction effects. For example, the dynamic response of a slender structure, like a wind turbine or a very tall skyscraper with a proportionally small footprint or shallow foundation, would be affected by interaction with the soil. Likewise, the response of a very rigid, heavy structure during an earthquake would be modified by soft foundation soil. ■

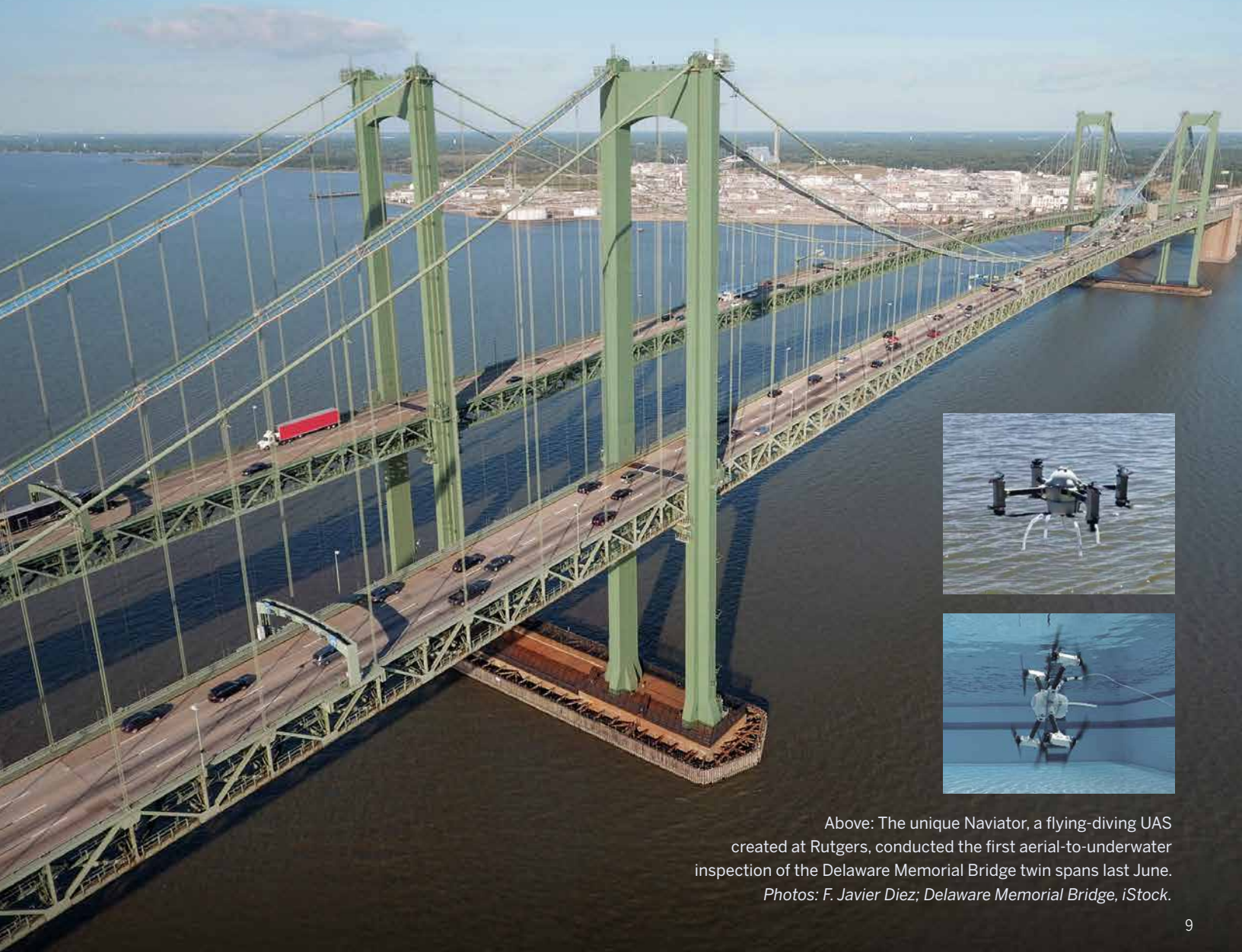


## >> There's something in the air

Drone innovations are flying high at Rutgers

During the past two years at Rutgers, research and development of unmanned aircraft systems (UAS) are literally and figuratively on the rise. Scores of specialized UAS missions are in the works, and research teams have piloted dozens of demos and test flights.

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Above: The unique Naviator, a flying-diving UAS created at Rutgers, conducted the first aerial-to-underwater inspection of the Delaware Memorial Bridge twin spans last June.

*Photos: F. Javier Diez; Delaware Memorial Bridge, iStock.*

Recreational drones far outnumber specialized commercial UAS. In 2016, around 110,000 UAS were sold for commercial use; that is expected to top 174,000 by the end of 2017. However, while the number of consumer drones is projected to be 2.8 million units by the end of 2017 (more than 15 times the number of commercial UAS), total revenues from commercial sales are nearly twice that of the consumer market.

Not only are commercial UAS more lucrative, they have practical value far beyond common hobbyist or photography drones. UAS being designed, built, or flown at Rutgers have expanded capabilities and perform specialized tasks. Though almost all drones in development have some sort of an onboard camera or imaging technology, they do much more than take pictures.

### There's an app for that

UAS have applications in transportation, construction, farming, public health and safety, humanitarian missions, and so much more. It now seems there are few tasks that these versatile tools can't make faster, easier, or more effective.

CAIT researchers were among the first to imagine multiple uses for drones in the transportation field, including as a cost-effective, more efficient, and safer method to conduct infrastructure inspections, looking for corrosion and other defects that could lead to big problems.

A 2013 CAIT-funded project led by Dr. Jie Gong used LIDAR to survey and record infrastructure damage caused by Hurricane Sandy.

LIDAR collects geospatial data in a point cloud that, when processed, recreates built environments in virtual reality that are accurate within two or three millimeters. This data provides crucial information about patterns of destruction after a disaster. LIDAR

data also can be used for countless other applications, from planning highway exchanges or drainage systems, to mapping the route for the space shuttle Endeavour when it traveled through the streets of Los Angeles.

There's just one downside: LIDAR surveying is expensive. So, CAIT is exploring other methods of 3D-data collection using drones. One current project is testing out photogrammetry as a lower-cost alternative to LIDAR.

### Unique UAS can inspect bridges from top to bottom and in between

The latest School of Engineering (SOE) drone to make a big splash is the unique Naviator, a flying-diving UAS, which conducted the first aerial-to-underwater inspection of the Delaware Memorial Bridge twin spans last June.

Created by mechanical and aerospace engineering professor Dr. F. Javier Diez and his team, the Naviator was initially developed under a \$500,000 contract from the Office of Naval Research (ONR). The first prototype launched in 2013. CAIT has been supporting development

of the Naviator for more than a year, acting as pilot-in-command and helping with logistics for demo missions.

"The Naviator's ability to seamlessly transition from flying to maneuvering underwater provides

**"... the best and brightest are getting degrees at Rutgers to stay and work in [drone technology]."**

— Stephen Sweeney, New Jersey Senate President

tremendous opportunities for a number of industries," said Diez on the day of the bridge inspection. "What previously might require a helicopter, boat, and underwater equipment, the Naviator was able to complete a single deployment [with fewer logistical hassles] and in less time, as it proved today."

The bridge inspection flight was a joint effort involving the Delaware River and Bay Authority (DRBA), SOE, CAIT, and SubUAS LLC, a company founded in 2016 to commercially develop and license this drone's technology under a Rutgers patent. CAIT research engineer Michael O'Connell was the pilot in command and Marco Maia was at the controls. Rutgers Center for Ocean Observing Leadership and numerous DRBA bridge and ferry employees provided support.

DRBA executive director Thomas J. Cook said, "We're pleased to be able to participate in this test demonstration. ... To have a single autonomous vehicle [conduct rigorous inspections] ... both above and below the waterline is no longer science fiction."

Cook and other DRBA officials agree that drones can make bridge inspections faster, more efficient, and safer. UAS inspections require fewer and shorter lane closures necessary to keep human inspectors safe, and that translates into less congestion and lower driver frustration.

Left: CAIT is experimenting with drone-deployed photogrammetry as an alternative to more expensive remote sensing methods for generating 3D models of transportation assets.

Image: Michael O'Connell/Rutgers CAIT, created with Pix4dMapper.







Crew for the Naviator bridge inspection test flight. (L to R) Michael O'Connell, Pilot in Command, Rutgers CAIT; Shekhar Scindia, Project Engineer III, DRBA; Jonathan Holzsgager, Test Coordinator, Rutgers Mechanical and Aerospace Engineering; Marco Maia, Test Pilot, Rutgers Mechanical and Aerospace Engineering; Brian Lutes, Project Engineer II, DRBA; and Jennifer Bristow, Project Engineer I, DRBA. Photo: DRBA/SubUAS/Rutgers CAIT.

"This effort stems not from our fancy with drones or trying to use gadgets," said DRBA project engineer Shekhar Scindia. "It is totally focused on making our annual inspections safer." He also estimates that Naviator could cut costs by 30 percent. On a major crossing like the Delaware Memorial Bridge, inspections can run as much as \$500,000; that savings would be a boon for both taxpayers and bridge owners.

The potential seems to be constantly expanding for the Naviator and other UAS like it. The original ONR project conceived Diez's invention as a tool for surveillance of ports or other homeland security targets, especially during emergencies when other safety systems may be compromised.

But with its "amphibious" abilities, several applications for the Naviator already have surfaced. It could perform search and rescue flights at sea, or evaluate storm damage to infrastructure with underwater elements, such as bridges, offshore drilling rigs, or submerged pipes and cables. It also could potentially be adopted for mapping the ocean floor and assessing environmental incidents like oil spills and algae blooms. Plus, the Naviator could be used in a broad range of tasks needed in emergencies, including humanitarian missions.

"[The Naviator] has opened up possibilities in novel markets that will find [its] capabilities advantageous," said Mark Contarino, vice president of technology at SubUAS LLC.

Its public debut was last summer at the "Drones in Disaster Do Tank" (an action-oriented version of a think tank) at which the Naviator team did a demo for groups involved in humanitarian activities: the Red Cross, five United Nations agencies including UNICEF, and the Humanitarian UAV Network, among others. Also in the audience were representatives from the Federation Aviation Administration (FAA), Senator Cory Booker's office, and the Navy War College. The event was cosponsored by CAIT and Flirtey, and organized by Field Innovation Team, Luftronix, and the New Jersey Innovation Institute at NJIT.

### Amplifying the buzz

The DRBA test flight and Do Tank demo are just two of many examples of Rutgers CAIT and other university teams taking the UAS show on the road—spreading the word by hosting and participating in events that promote the technology's value and versatility.

One of the most progressive transportation groups in the country, the Intelligent Transportation Society (ITS), emphasized UAS applications at the New Jersey annual meeting in late 2016, pointing out drones' broad capabilities to monitor and deliver a range of data that is critical to smooth, safe transportation operations.

For a tangible example, CAIT researcher and SOE assistant professor Peter J. Jin set up a mock roadway crash scene and live-streamed video from

a drone to the ITS conference audience. This demonstrated that a comprehensive, real-time "eye-in-the-sky" UAS would be useful for mobilizing incident responders and recording important accident data, even before officials are on the scene. A live view also can help police determine if they need to divert traffic upstream of the crash.

As a leader in UAS development, Rutgers often is called upon to help organizations understand potential applications for drones.

At the request of New Jersey Department of Transportation (NJDOT) Assistant Commissioner William Kingsland, Rutgers and NJIT presented a range of possibilities at the NJDOT UAS Summit in late 2016. The summit targeted stakeholders whose attitudes toward drones range from skeptical to cautiously supportive. In some cases, agencies' hesitation is just due to not being able to imagine how UAS could fit into their routine operations.

Nearly 100 attendees from NJDOT, the New Jersey State Police, the Department of Environmental Protection, DRBA, the Delaware Valley Regional Planning Commission, and several other agencies were at the UAS Summit for a Rutgers demo launched from the DOT maintenance yard. The UAS fed real-time video to the audience, inspiring visions of how drones could be a go-to tool for daily tasks—conducting pavement condition surveys, keeping track of maintenance equipment and inventory, and monitoring traffic.

Right: There are ample opportunities for students to get hands-on experience with building and testing UAS at Rutgers, even generating components with 3D printers. Photo: ©Nick Romanenko/Rutgers.

<< p11 Something in the air

Last December, New Jersey Senate President Stephen Sweeney (D-Gloucester) invited researchers from Rutgers, NJIT, Stevens Institute of Technology, Rowan University, and Stockton University to a roundtable event at the New Jersey State House for the purpose of updating legislators on current drone research and to discuss opportunities for collaboration. Researchers presented examples ranging from emergency communications links for first responders to marketing real estate.

At that event, Christopher J. Molloy, Rutgers senior vice president for research and economic development, told the audience, “Rutgers’ UAS researchers are developing technologies for a wide range of critical applications and a number that are particularly valuable for New Jersey ... to assist with traffic incident management, for coastal research, and for mosquito-control operations.”

Sweeney pointed out that the use of drones is accelerating, and five New Jersey universities are leading the charge as far as identifying applica-



tions for unmanned aerial devices, responding to needs for customized units, and attracting high-quality students whose talents can bolster the state’s economy.

“In a few years [drone technology] is going to be a couple-billion-dollar industry annually, and the best and brightest are getting degrees at Rutgers to stay and work in these fields.” He said lawmakers could consider incentives for universities to continue advancing drone technology.

### Steadily gaining altitude

A credit to the university’s record for innovation, on the 2016 National Academy of Inventors list of the world’s top universities, Rutgers ranked #27 based on the number of U.S. utility patents issued for the prior year. Projects at Rutgers also

have spurred more than 50 startup companies currently open for business.

There are plenty of complex issues we have yet to navigate as drones pervade U.S. airspace, industries, and our lives; safety and privacy are two of them.

(See sidebar on regulations, page 13.)

There are technical hurdles to overcome as well, such as balancing the cost, flight time, and payload capacity for “workhorse” UAS, and perfecting autonomous operation using complex preprogrammed flight patterns or algorithms and onboard sensors that allow a drone to shift course and avoid sudden obstacles on-the-fly.

In a 2016 publication, “Drones Reporting for Work,” Goldman Sachs pointed out that UAS are becoming powerful business tools. An estimated \$100 billion will be spent on military and civilian drones from 2016 to 2020. Of that total, the commercial segment is predicted to be the fastest-growing, particularly in construction (\$11.2 billion), agriculture (\$5.9 billion), insurance (\$1.4 billion), and infrastructure inspection (\$1.1 billion). Oppenheimer & Co., predicts that the commercial market “will ultimately contribute the majority of UAV industry revenues.”

Total economic impact of the UAS industry in the United States alone is expected to increase around \$2 billion per year between now and 2020. Rutgers leadership and researchers are confident the university will launch plenty of soaring breakthroughs in the commercial UAS sector. ■



Left: CAIT has been doing outreach, showing agencies and lawmakers the broad range of applications for drones in daily operations at events such as this roundtable at the New Jersey Statehouse.

Photo: Courtesy New Jersey Legislature.



# Drones give rise to unique regulatory challenges

The future of UAS commercialization will be influenced as much by lawmakers and regulators as it will be by technological innovations

The race is on between policy makers who want to ensure safety and companies eager to put rapidly advancing drone technologies to work. The rapid growth of consumer drones in America made it necessary for the Federal Aviation Administration (FAA) to confront some of these issues.

Early on, the FAA required public UAS operators to apply for a Certificate of Authorization (COA). A comprehensive operational and technical review were part of the lengthy and expensive process to gain approval, that when granted, was often for a specific, narrowly defined UAS activity bound by strict limitations. That procedure has been replaced by a set of rules issued by the FAA in August 2016, known as “Part 107.” These rules now dictate the conditions under which commercial drones may operate. A decade in the making, Part 107 allows operators with a remote-pilot certificate to fly a drone for commercial purposes during the day, within the line of sight, in uncontrolled airspace, at a maximum altitude of 400 feet.

Before FAA introduced Part 107, some countries were outpacing the United States because

their approach to drone development and testing was more lax. Amazon did their early delivery-by-drone testing in Canada, and Google’s X laboratory tested drones in Australia where regulations were less restrictive. France’s relatively permissive regulations put it in the lead for use of drones in of agriculture. In Britain, a drone cluster sprung up around an airport in Wales, where there are drone-friendly policies and facilities.

## Pushing the envelope

Part 107 cleared commercial drones for takeoff—not just in America, but also worldwide—and its rules are now globally viewed as the best model. But some countries already are loosening the leash, trying to gain a competitive edge. France and Switzerland allow some operation beyond visual line of sight, and in 2018 Japan will phase in delivery drones.

In the United States, commercial UAS operators and researchers can be exempted from some restrictions of Part 107 via special waivers from the FAA, as long as additional safety requirements set by the agency are met. Getting a waiver for nighttime operation, for example, requires

mounting a light on the drone that is visible three miles away, and establishing proficiency for night-flight operators. Waivers benefit the industry and the FAA because they provide a sort of “test flight” for regulations prior to committing them as formalized policy.

In spite of fierce competition to attract startups and dominate marketshare, regulators in different countries are working closely together, attending each other’s meetings and learning from each other. “It’s very good for the industry, because every nation wants to be a leader,” says Greg McNeal, a Pepperdine University law professor who advises the FAA on drone regulation.

Other rule changes expected within the next few years include authorizing control of multiple drones by a single operator, night flights, flights over people, and, eventually, flights beyond visual line of sight, which is a crucial allowance for delivery drones.

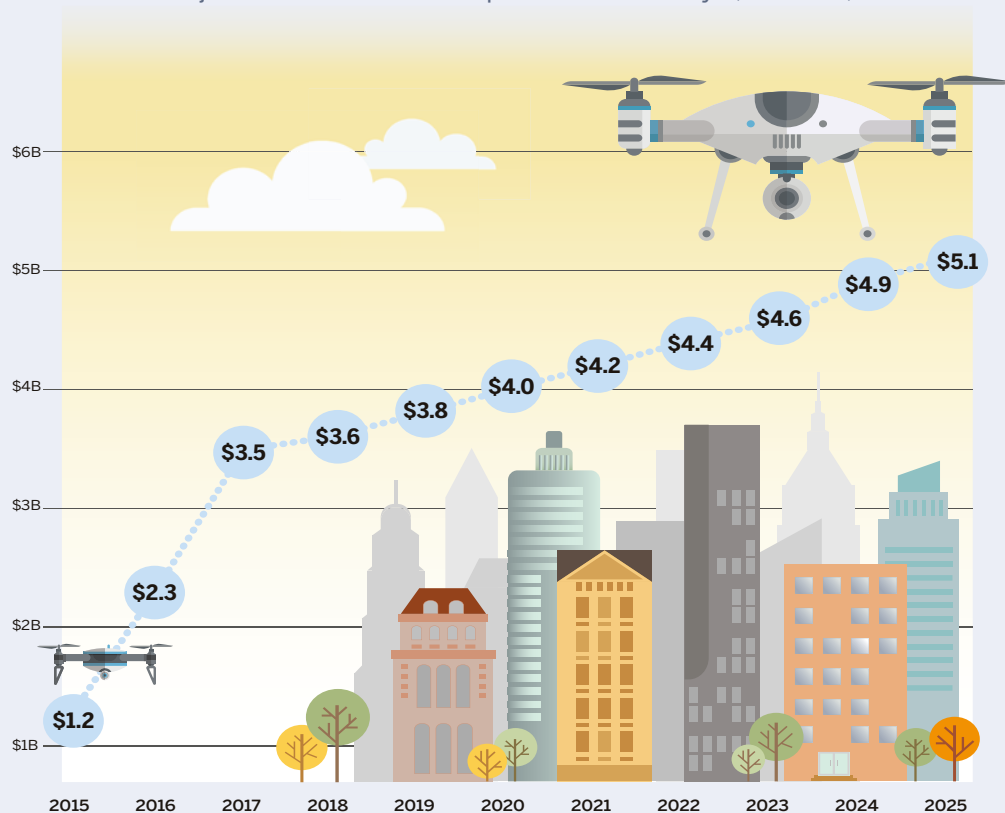
## Out of sight, out of control?

The U.S. air-traffic-control systems for airplanes currently are operated manually by human controllers coordinating with human pilots, but that won’t work for unmanned drones flying in much larger numbers. Once hundreds of drones are flying beyond their operators’ watchful eye, especially in urban and densely populated areas, a more elaborate system will be needed to track them and make sure they avoid buildings, power lines, bridges and other infrastructure, manned aircraft, each other, and, of course, people.

DJI, the Chinese company that holds 70 percent of the consumer drone market, makes UAS that already support “geofencing,” a software feature that uses GPS or radio frequency identification to define geographical boundaries. A database of where drones are and are not allowed to fly can be built into the software that controls them, working with satellite positioning to prevent an operator from flying a drone too close to an airport, for example. Some databases can be updated in real time to keep drones away from unexpected scenarios such as fires and other emergency situations.

Parimal Kopardekar of NASA’s Ames Research Center is leading the development of an automated UAS Traffic Management (UTM) system. With the UTM system, drones file requests to use

Projected direct economic impact of UAS industry\* (US\$ in billions)



\* Data includes all UAV-linked spending on employees, construction, purchasing, development, and investment in UAS technology. Source: Association for Unmanned Vehicle Systems International, 2013.

particular flight paths with a local data exchange, which then coordinates all the movements. Last year NASA carried out a trial of its UTM architecture across the United States, which revealed several challenges, notes Kopardekar. In particular, it turned out that fixed-wing and multirotor drones respond very differently when they encounter rising columns of air, called thermals. Fixed-wing drones “bounce around quite a bit, by a few hundred feet,” says Kopardekar, which means drones cannot be stacked too closely together. Route planning will, in short, require a detailed understanding of micro-climates and of the behaviors of different types of drones. Building the necessary systems will take a few years.

The FAA plans to introduce the first rules relating to UTM in 2019. Drones will need to be equipped with “sense and avoid” systems and long-range radio to communicate with each other and with the data exchange. That also poses a challenge, says Jane Rygaard of the network equipment maker Nokia. Rygaard explains that existing mobile networks are designed to work with users on the ground, not in the air. Networks will have to be augmented with antennae that point skyward. This technology currently exists to provide in-flight connectivity to aircraft, but will have to be greatly extended to take in drones as well. It is clear that the complexities of operating drones in large numbers have barely begun to be understood.

These flying marvels embody the extraordinary power of digital technologies. Trying to imagine how drones will evolve could be compared to forecasting the future of the personal computer in the 1960s or mobile phones in the early 1980s. There was a set of expected applications for those tools at the time, but then the technology developed in unexpected ways. The same will likely be true of drones. Because they operate in the physical rather than the virtual world, capitalizing on their many promising uses will depend just as much on sensible regulation as on technological progress. ■

*The regulations summary above was adapted using excerpts of an article that appeared in the June 8, 2017, issue of The Economist, “Technology Quarterly: Taking Off.” The full article is available at [economist.com/technology-quarterly/2017-06-08/civilian-drones](http://economist.com/technology-quarterly/2017-06-08/civilian-drones).*

## NJDOT wants to hear your bright idea

Bureau of Research launches its modern suggestion box

**New Jersey Department of Transportation (NJDOT)** announced the launch of a new website for NJDOT Bureau of Research customers and stakeholders to share their thoughts regarding projects that could improve transportation for residents, workers, visitors, and businesses throughout New Jersey. The Ideascale website is a tool for gathering ideas about issues of safety, mobility, and accessibility that potentially can be addressed with methodical, well-defined research. The bureau aims to use its customers’ suggestions as first step in developing fundable research proposals.

**Who are NJDOT customers?** NJDOT Bureau of Research customers and potential customers include NJ TRANSIT, New Jersey Motor Vehicle Commission, MPOs, county and local governments, and subject matter experts from industry, trade groups, universities, NGOs, and even other departments within NJDOT.

**Why research?** The Bureau of Research works with university and other research professionals to find solutions for some of the state’s most confounding transportation issues. Partnering with academic and other experts supplements the agency’s in-house expertise.

Research can be a wellspring of solutions that can quickly transition into use on our roads, bridges, and rails. NJDOT taps brainpower inside and outside the agency to find applicable, practical ways to enhance the quality and cost effectiveness of the practices, standards, and specifications that are used in planning, building, and maintaining our infrastructure.

**Who can participate?** Any committed professional in the transportation field can participate. A research idea typically needs a “champion.” Ideally, this is an individual who holds a responsible position within a division, department, or other unit, and is prepared to sponsor, support, or advance a research idea from its inception to completion.

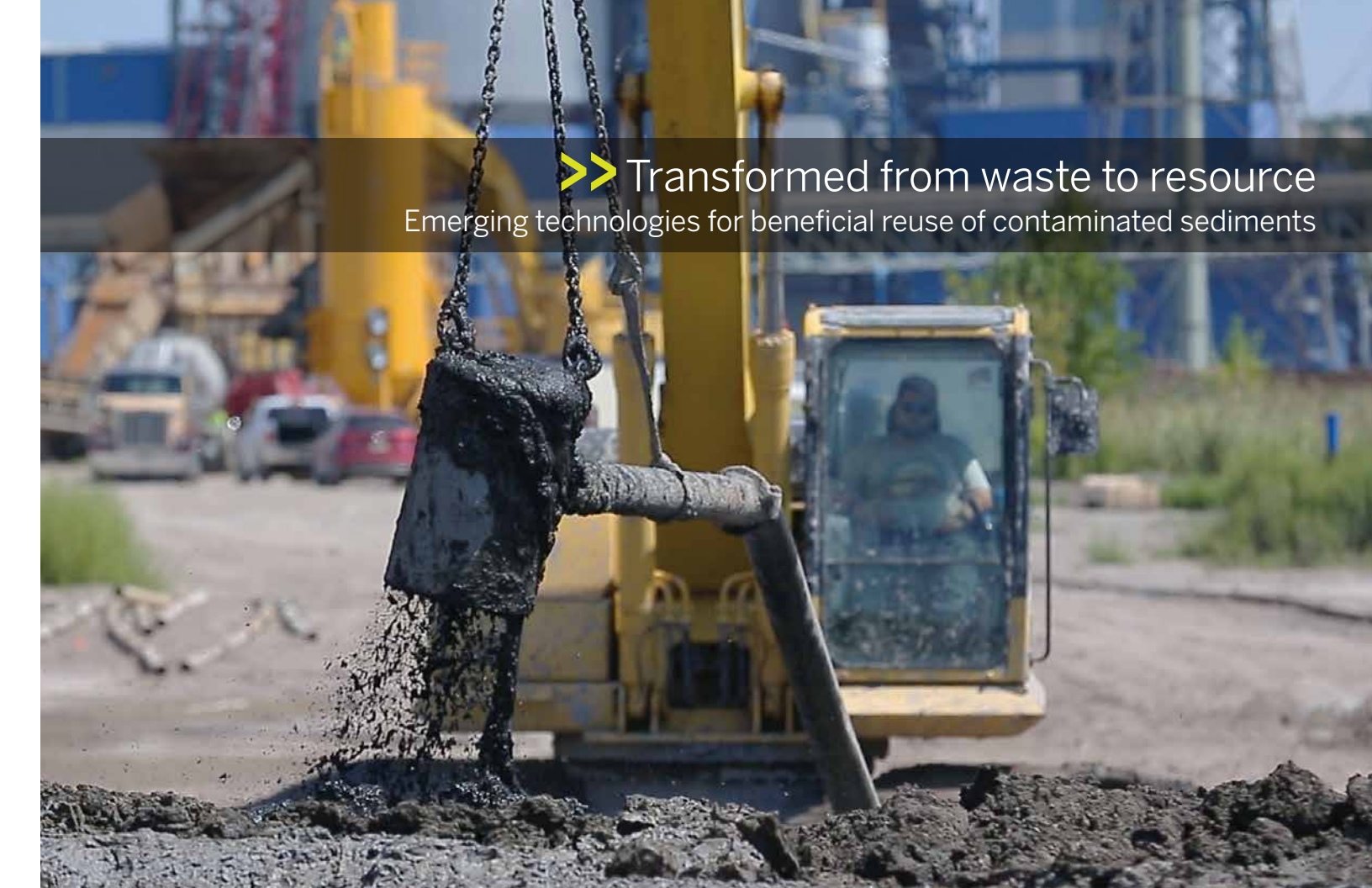
To submit an idea, you have to register. Go to [njdottechtransfer.ideascale.com/a/home](http://njdottechtransfer.ideascale.com/a/home) and click “register” in the top right corner of the page. After registering, submit your bright idea by clicking the red “Submit New Idea” button. You also can comment on other users’ ideas or vote for ones you support.

Submissions on the site are reviewed and prioritized by the Research Oversight Committee, then, those deemed most valuable will be developed into requests for proposal (RFP) and posted on the NJDOT RFP web page, [state.nj.us/transportation/refdata/research/research\\_procurement.shtm](http://state.nj.us/transportation/refdata/research/research_procurement.shtm).

So, if you have an idea to make transportation better, share it on Ideascale. It just might get a green light. ■







## >> Transformed from waste to resource

Emerging technologies for beneficial reuse of contaminated sediments

It is hard to envision the amount of mud and silt dredged from the New York/New Jersey Harbor for projects like a recent one that deepened it to accommodate post-Panamax ships. According to the U.S. Army Corps of Engineers, 52 million cubic yards of dredged material was removed for the channel-deepening project—enough to fill MetLife Stadium nearly two-and-a-half times.

Generally, sediment dredged from the region's harbors is very fine-grained and has to be amended with cement or other additives to make it stable enough for structural applications. In the case of contaminated sediment, another priority is keeping pollutants like heavy metals, pesticides, and PCBs contained so they don't leech into the groundwater or in storm runoff.

Professionals in sediment management are always looking for new technologies, more efficient methods, and improved processes to manage dredged material.

In mid-November 2017, Rutgers CAIT hosted a workshop on emerging trends in the management of contaminated sediments. The event was a joint effort with Ramboll Environ, an international environmental, safety, and health sciences consulting firm. People from industry, government agencies, and academia gathered for presentations on the latest advances and to discuss several challenges those working in this field still face.

During the workshop presentations and Q&As, one theme that emerged was the extent to which regulations, public perceptions, and available/affordable technologies influence how we manage these materials.

"What works today isn't always going to work," said W. Scott Douglas, director of the Office of Maritime Resources at NJDOT. Douglas worked with CAIT to develop "The Processing and Beneficial Use of Fine-Grained Dredged Material," a definitive manual on the subject that was published in 2013. According to Douglas, the public's growing distaste for confined disposal facilities—landfills where dredged materials have traditionally been stored—bolsters a shift toward beneficial reuse of all dredged sediments, including those contaminated by New Jersey's 200-plus-year history as an industrial powerhouse.

Matthew Jokajty, environmental counsel at PSE&G, presented an overview of the history of dredged material management in New York and New Jersey and current regulations.

Above: CAIT brought pneumatic tube mixing (PTM) to the United States for the first time and did a pilot project to quantify and validate it as an effective technique for our region. Photo: ©Drew Noel Photography/Rutgers CAIT.



Left: People from industry, government agencies, and academia came to learn about the latest advances and to discuss ongoing challenges. Photo: ©Allison Thomas/Rutgers CAIT.

Below: Contaminated dredged material—at one time just dumped in the ocean—is now used for construction projects, brownfield reclamations, habitat restoration, and other applications.

## << p15 From waste to resource

In the mid 1990s, closure of the “Mud Dump” site off Sandy Hook jeopardized a plan to deepen channels to the Port of New York and New Jersey. With open-water dumping unavailable, officials were left wondering what to do with millions of cubic yards of contaminated estuarine mud.

In 1996, the Dredging and Harbor Revitalization Bond Act put in motion a gradual change in both attitudes and practices that led officials to deem dredged material a resource, not solid waste. That ushered in regulatory programs and a New Jersey legislative mandate for NJDOT and NJDEP to encourage beneficial reuse and provide legal protections for placement of dredged material. The 1997 Brownfields Law offered incentives such as federal assistance, and made beneficial reuse more attractive to entities that willingly agreed to use dredged material in the cleanup and remediation of their contaminated properties.

At the workshop, presentations by CAIT director Dr. Ali Maher, environmental sciences associate professor and CAIT researcher Dr. Robert Miskewitz, and Juha Forsman from Ramboll Finland focused on technological innovations coming to the fore.

Maher reviewed state of practice for management of contaminated sediment in North America.

Miskewitz highlighted ongoing research by the CAIT Soil and Sediment Management Lab, including a demonstration project implementing and validating the pneumatic tube mixing method (PTM), investigations into solidification/stabilization binder innovations, ex-situ erosion testing (ESTEM), cohesive sediment resuspension, and in-situ metal sensors.

Forsman discussed requirements and cases for solidification/stabilization additives in Finland and other Nordic countries, where it is cold for much of the year and soils are soft, cohesive, and wet. He identified several promising combinations, including cement and industrial by-products like Estonian oil shale fly ash. Presentations by Tommi Marjamäki, also from Ramboll Finland, and Raj Singh from Ramboll Environ, underlined that innovation and optimization were key to wide implementation of cost-effective and environmentally sustainable geotechnical solutions.

As is the case with many environmental issues, the length and cost of reuse projects were identified as major barriers. Eric A. Stern, adjunct faculty in earth and environmental studies at Montclair State University, juxtaposed the time-scale of sediment remediation projects (on the order of decades) with common social timelines (several years) to highlight the inefficiencies of today’s risk assessment world. He emphasized the need to “give a face” to sediment management, and improve communication of sediment challenges to minimize disconnects between policy, science, and engineering. Potential ways to address project costs that were discussed included cost-sharing mechanisms, the commodification of treated dredged material, and optimizing binding agents for contaminated sediment stabilization.

Finally, workshop attendees discussed the integration of sediment management with coastal resilience, habitat restoration, offshore wind, and other large infrastructure projects and how to make them greener and/or more economically feasible. Jay Borkland (Department of Civil and Environmental Engineering, Tufts University and Ramboll Environ) presented a comprehensive case study of contaminated sediment management projects for the rehabilitation of New Bedford Harbor in Massachusetts, leading up to the development of the nation’s first offshore wind port facility, the New Bedford Marine Commerce Terminal.

Overall, the workshop was a meaningful and collaborative event aimed to share knowledge and foster enthusiasm for the future of beneficial reuse. It was an opportunity for attendees to share experiences and design solutions across the agency-industry-academic spectrum that contributes to sediment management solutions. The event will potentially be held annually, further connecting CAIT’s cutting-edge research with industry and government agency partners. ■





## Think nationally, act locally

LTAP and TTAP centers translate large-scale transportation ideas into local action

Across the country, local and tribal agencies are responsible for more than three million miles of roads and over 300,000 bridges—roughly 75 percent of the roadway network in the United States. Cities and towns, rural and urban communities, and counties big and small, face a multitude of complex issues to run the transportation systems they are responsible for.

Janet Leli, CAIT's associate director of technology transfer and director of the New Jersey Local Technical Assistance Program (NJLTAP), wrote an article in the July/August 2017 edition of the Transportation Research Board magazine, *TR News*, about the role of local and tribal transportation centers.

In 1982, the Federal Highway Administration (FHWA) began an initiative in response to local agencies' needs for training and technical support. In 1991, that original program evolved; it was renamed the Local Technical Assistance Program (LTAP) and created the Tribal Technical Assistance Program (TTAP) to provide the same services for tribal governments. These programs help local and tribal transportation agencies build, maintain, and operate U.S. roadways by delivering targeted training, guidance, and resources. Today, the LTAP/TTAP network consists of one LTAP center in each state, one in Puerto Rico, and one national TTAP center.\*

LTAP and TTAP networks are conduits for information and training on new technologies, methodologies, and best practices in transportation. They also are known as technology transfer centers because they take technical information and best practices from national agencies and professional organizations (e.g., FHWA, AASHTO, APWA, NACE, etc.) and state DOTs, and make sure the knowledge reaches local "boots on the ground."

Areas that training and resources are available in run the gamut: maintenance, asset management, roadway and work zone safety, congestion reduction strategies, safe options for pedestrians and cyclists, and new federal and state regulations. Likewise, the LTAP/TTAP target audience is geographically and professionally far-reaching: it includes public works directors and crews; city, town, and county engineers; transportation planners; and road maintenance superintendents and staff. LTAP/TTAP even serve state DOTs, metropolitan and rural planning organizations, regional planning agencies, and private consultants.

LTAP/TTAP centers provide training programs; technical updates; a variety of valuable resources; and personalized assistance. Leli says, "The centers will even tailor tools or programs to a particular agency's needs, and employ a 'peer-to-peer approach' in which centers may share training material or newsletter articles and refer subject-matter experts."

An example of LTAP and TTAP encouraging new approaches was how they promoted the FHWA/AASHTO program, Every Day Counts (EDC), through newsletters, demonstrations, workshop training, multimedia products, and a series of webinars. The goal of EDC was to improve efficiency via a range of proven approaches. EDC Exchange Webinars produced by LTAP/TTAP focused on project development and delivery and facilitated local discussion exploring potential implementation of the recommended practices, tools, and products.



The end result led to "increased implementation of the innovations by local and tribal transportation systems," Leli writes.

LTAP and TTAP centers demonstrated the advantages of ultra-high performance concrete (UHPC), an initiative of EDC, and provided technical assistance and training, which led the Vermont Agency of Transportation to use UHPC.

Another example Leli cites in the article is how through exposure and education LTAP centers spread adoption of a new asphalt paving system, Superpave. The Superpave system ties asphalt binder and aggregate selection into the mix design process, and considers traffic and climate in the process. When local agencies in New York State first learned of Superpave, New York State LTAP director David Orr said it was considered a "sophisticated technology" so they were reluctant to use the product. After Orr's team began demonstrating how easy it was to use Superpave and how well it performed, it was accepted as a standard.

LTAP and TTAP centers partner with state DOTs to host Research Showcases for transportation professionals to see innovations already in use or being developed by researchers in their own state. They invite participation with the "Build a Better Mousetrap," a national competition in which local and tribal transportation workers nominate their choices for innovative solutions to their everyday problems.

Through proven engagement strategies—communicating, making information easier to understand, offering training, and introducing and demonstrating technologies—LTAP/TTAP centers show local transportation agencies how to take advantage of advances that provide practical solutions to the specific challenges they face, even with limited resources. That's good for them, and good for their communities.

**More on the web:** For additional information, go to [cait.rutgers.edu/njltap](http://cait.rutgers.edu/njltap), [www.nltapa.org](http://www.nltapa.org), and [www.fhwa.dot.gov/innovativeprograms/centers/local\\_aid](http://www.fhwa.dot.gov/innovativeprograms/centers/local_aid). ■

\*Prior to program restructuring announced in December 2017, there were seven TTAP centers serving tribal governments.

## Research show and tell

### 19th Annual NJDOT Research Showcase recap

The New Jersey Local Technical Assistance Program (NJLTAP) hosted the NJDOT 19th Annual Research Showcase on October 25 at the Conference Center at Mercer, in West Windsor, NJ. Approximately 250 professionals from NJDOT, FHWA, NJ Transit, New Jersey Motor Vehicle Commission, local government agencies, private industry, and universities attended. NJLTAP offices are based at CAIT.

Keynote speaker Jim Shurbutt, exploratory advanced research program coordinator at FHWA Turner-Fairbank Highway Research Center, addressed the theme of the showcase, “The Exploratory Search for Innovation and Mobility.”

NJDOT Bureau of Research manager Amanda Gendek and David Aimen, assistant director for planning and technical assistance at Rutgers Voorhees Transportation Center, spoke about NJDOT’s Innovation Program.

The day also featured presentations from other notable speakers: Roger Lall, acting assistant division administrator at FHWA–NJ Division; Mike Russo, assistant commissioner of capital investment, planning, and grant administration for NJDOT; and Bernardo Kleiner, a transportation safety specialist and senior program officer at the Transportation Research Board.

The morning plenary session highlighted recent successes of NJDOT’s Unmanned Aircraft Systems (UAS) program, including a NJDOT-sponsored UAS peer exchange, led by speaker Glenn Stott, UAS Coordinator, NJDOT.

At the end of the morning activities, NJDOT publicly recognized selected research, innovation, and implementation efforts with presentation of the 2017 Outstanding University Student in Transportation Research Award,



NJDOT Research Implementation Award, Best Poster Award, and NJDOT Innovator Award.

Also, throughout the day, high traffic in the research poster exhibit highlighted additional research projects and provided an opportunity for students involved in research to share their work.

In the afternoon, attendees could choose from a series of breakout sessions on the topics of environment, infrastructure, safety, and intelligent transportation systems.

Through these sessions and discussion with other attendees, NJDOT customers learned about ongoing technology transfer activities and academic research being conducted through the NJDOT Bureau of Research by its university research partners and their associates. ■

## ASCE honors two CAIT civil engineers

The ASCE Central Jersey Branch honored two Rutgers researchers at its annual awards dinner on October 19, held this year at the Forsgate Country Club in Monroe Township.

**Dr. Franklin Moon**, professor of civil and environmental engineering, was chosen as “Educator of the Year.” Moon joined the Rutgers School of Engineering in January 2016, but had been a long-time affiliated research partner with CAIT, notably on the FHWA Long-Term Bridge Performance Program.

Moon is a widely respected expert in infrastructure performance and vulnerability. He is especially knowledgeable in the areas of sensing technologies, structural identification, structural health monitoring, numerical modeling, and estimation of service life.

In 2016 he won the prestigious ASCE Pankow Award for Innovation for a bridge evaluation device he developed with partners at Drexel University and Intelligent Infrastructure Systems. THMPER™, a portable, stand-alone, highly accurate rapid testing device, combines modal impact testing, refined analysis, and finite element model calibration to determine bridge load-bearing

capacity. It is a breakthrough because it does this critical task faster, cheaper, and with less traffic disruption than other methods.

Moon is a member of the ASCE Industry Leaders Council, Innovation Committee, an associate editor for the ASCE *Journal of Structural Engineering*, and a council member of the International Society for Structural Health Monitoring of Intelligent Infrastructure.

**Dr. Mohammad Jalayer**, a CAIT research associate, received the “Young Civil Engineer of the Year Award.” Jalayer has more than nine years of experience in traffic engineering and has been deeply involved in research related to traffic operations and safety, intelligent transportation systems (ITS), and access management.

He is an associate member of ASCE T&DI Transportation Safety Committees, a member of ITE and ASCE, and friends of TRB standing committees on safety data, analysis, and evaluation; highway safety performance; roadside safety design; access management; and ITS. ■





Documentary profiles a man obsessed with transportation

Darius McCollum is a grown man with Asperger's syndrome who has had a singular focus on public transit since he was eight years old.

He has an encyclopedic knowledge of the Metropolitan Transportation Authority (MTA) procedures, policies, schedules, and routes. He has collected fares and maintained tracks, but is happiest in the driver's seat of a New York City subway or bus. He has attended transit worker union meetings, lobbying for pay increases and better working conditions for members of a union he doesn't belong to.

Darius has never caused or been involved in an accident. He hasn't damaged any property or injured anyone. When operating a train or bus, he always rigorously follows the prescribed route and makes every stop on time. He has never asked to be paid and has not received any compensation for his competent service. There's just one problem: Darius doesn't work for the MTA.

He has been arrested more than 32 times for impersonating subway conductors and bus drivers and commandeering their vehicles. Sadly, his criminal record and mental issues make the solution to his obsessive problem impossible. He will never be employed by the agency that could make his dreams come true.

In *Off the Rails*, director and producer Adam Irving recounts Darius' complicated history, which

has been marked by an inability to resist his compulsions and endless recidivism. When he "borrows" a transit vehicle, his on-the-job performance is exemplary. His crimes have been victimless, which makes the fact he has spent more than 23 years in maximum security prison even more distressing.

Darius was mercilessly bullied as a child. He once was attacked with scissors by another youth. That incident precipitated a great distrust of his peers and triggered looping behaviors: running away, getting committed and put on psychotropic medication, getting well enough to be released, and starting the cycle again.

In the late '70s, he frequently took refuge in the subway system, showing a curiosity that ingratiated him with the workers, some of whom went so far as to unofficially train him in various capacities. He made the news in 1981, at age 15, when he got caught joyriding (or rather joy-driving) the E train, having properly announced and made eight stops. A conductor friend who wanted to sneak off to see his girlfriend had asked Darius to take over for him.

For the next three decades he was "driven to drive," reoffended literally hundreds of times, and got stuck in the revolving door of the justice system. When he was out of prison, finding a job—any job—was near impossible because he carried the dual stigma of a developmental disability and a felony record. His lack of income led to sporadic homelessness and deteriorating mental health. By 2010, he was serving his 29th incarceration at age 45, without the attention, therapy, or legal options he needed.

"I'm really good with trains, but I can't seem to figure out people," Darius says, after having spent half his adult life in prison.

Our criminal justice system—and society—failed Darius McCollum, a harmless, passionate, mentally challenged person who, with proper guidance, could have had a productive career in transportation and a purposeful life. ■

## >> transportation today

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**More on the web:** Visit [www.offtherailsmovie.com](http://www.offtherailsmovie.com) to learn more. The film is available streaming on Sundance Now (free trial available) and iTunes, and available on DVD from Netflix.

*Photo above from Off the Rails website trailer.*



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